When the Earth Trembled, the Statues Fell

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On July 8, 1987 at 11: 50:14.9, Easter Island experienced a major earthquake with a magnitude of Ms=6.3, succeeded by several tremors which measured up to Ms=5.9. The epicenter was located at 26.999 south latitude and 108.285 west longitude at a depth of 10 kilometers and slightly westwards of the island. See trace of the quake in Fig. 1.

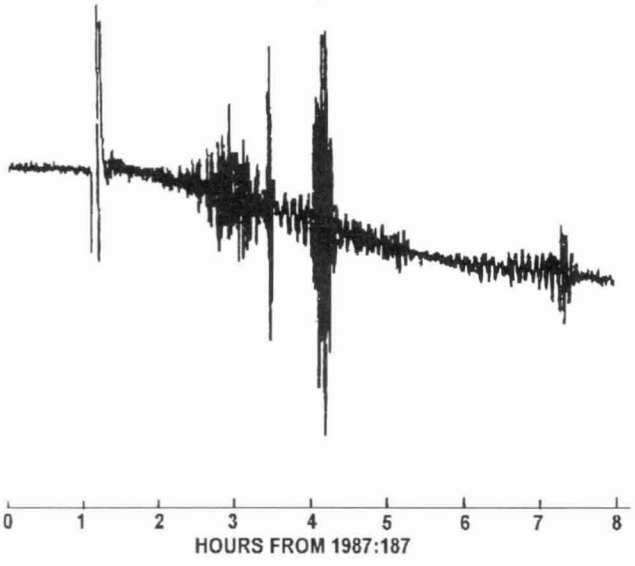


Figure 1.Trace of earthquake on Easter Island in 1987.

For some Easter Islanders this was very frightening. It was the first time they experienced an earthquake, and it was particularly scary for those who were alone at the time because they did not know if this was a phenomena affecting all of the island, or something they only were experiencing. Some believed it was supernatural or 'devilish' because the tremors were accompanied by strange underground noises like 'growling'. Many began praying for their salvation. However, for the majority of the islanders it was identified as an earthquake for some had experienced these before on the Chilean mainland or heard about them from their parents.

Natural events of this nature would have produced a profound effect on Polynesian inhabitants in the past, especially if strong seismic activities continued over a long period of time. This could explain why some, or perhaps most, of the giant stone statues fell from their pedestals and why many of the giant stone statues that were near completion were abandoned at the quarry of Rano Raraku. If the statues were falling, why continue carving them?

That the statues could have fallen in an earthquake is not an original idea. J. R. Förster, one of the naturalists on Cook's second voyage in 1776, mentions that when he visited the ceremonial center of Ahu Vinapu on the southwest coast of Easter island, he was surprised to find that there were three fallen and four statues still standing, one of which had lost its topknot. He thought this event could have occurred "perhaps by an earthquake" (Förster 1982: 465). Assumptions that some kind of volcanic catastrophe could have been the cause for the toppling of the statues was later adopted by A. Agassiz (1900:33) who suggested that volcanic eruptions and great earthquakes were the cause of the destruction of the megalithic monuments. Unfortunately, in later years these assumptions were either forgotten or dismissed, until the most recent earthquake struck in 1987.

The tectonic environment of Easter Island

Easter Island is located in the South Pacific Ocean at 27.09 south latitude and 109°23' longitude west, at about 3700 kilometers from the coast of Chile and 500 kilometers to the east of the dorsal axis of the Oriental Pacific Cordillera (Fig. 2). According to Gonzales-Ferrán (1974:1987), "It is a young volcanic island of the 'Oceanic' type structured by a complex effusive cycle that culminated in the development of several eruptive centers. Its triangular form is due to the action of marine erosion upon its coasts and it has an approximate surface of 172 square kilometers with a maximum height of 560 meters above sea level at the summit of Mt. Terevaka.

The structural characteristics of its eruptions are due to its proximity to the Active Oceanic Rift in the Oriental Pacific Dorsal, and were clearly controlled by its petrography and petrochemic properties that show the typical genesis of oceanic volcanism of a 'hot spot' associated with a dynamic processes of plate tectonics. Easter Island is located on the Nasca plate (Figs 2 and 3) immediately east of the microplate of Rapa Nui that intercepts the Pacific Dorsal and it is in a zone of the Volcanic Transpacific Fracture known as 'Easter Island Hot Line'. Other volcanic islands located upon this same fracture are Sálas y Gómes, San Felix and San Ambrosio, and numerous submarine volcanoes that give continuity to this 'hot line' towards the east.

The volcanic triangle of Easter Island raises 3000 meters above the ocean floor and its trapezoidal oceanic base measures approximately 130 x 90 by 100 km. This means that its basal surface is nearly fifty times larger than the island's present surface and its form follows the structure of a typical volcanic shield (Fig. 4).

Seismographic records for Easter Island

The first seismographic records of earthquakes in the proximity of Easter Island were recorded by a seismograph installed in 1911 by Mr. Edgardo Martines who was sent to the island on a mission by Mr. Montessus de Ballore, Director of the Chilean University Seismographic Service. That year many earthquakes were recorded and felt by the islanders who called them '*Papa-papa'* which means 'trembling'. Apparently this is an ancient word as it is mentioned in Father Roussel's *Dictionary of the Easter Island Language*,

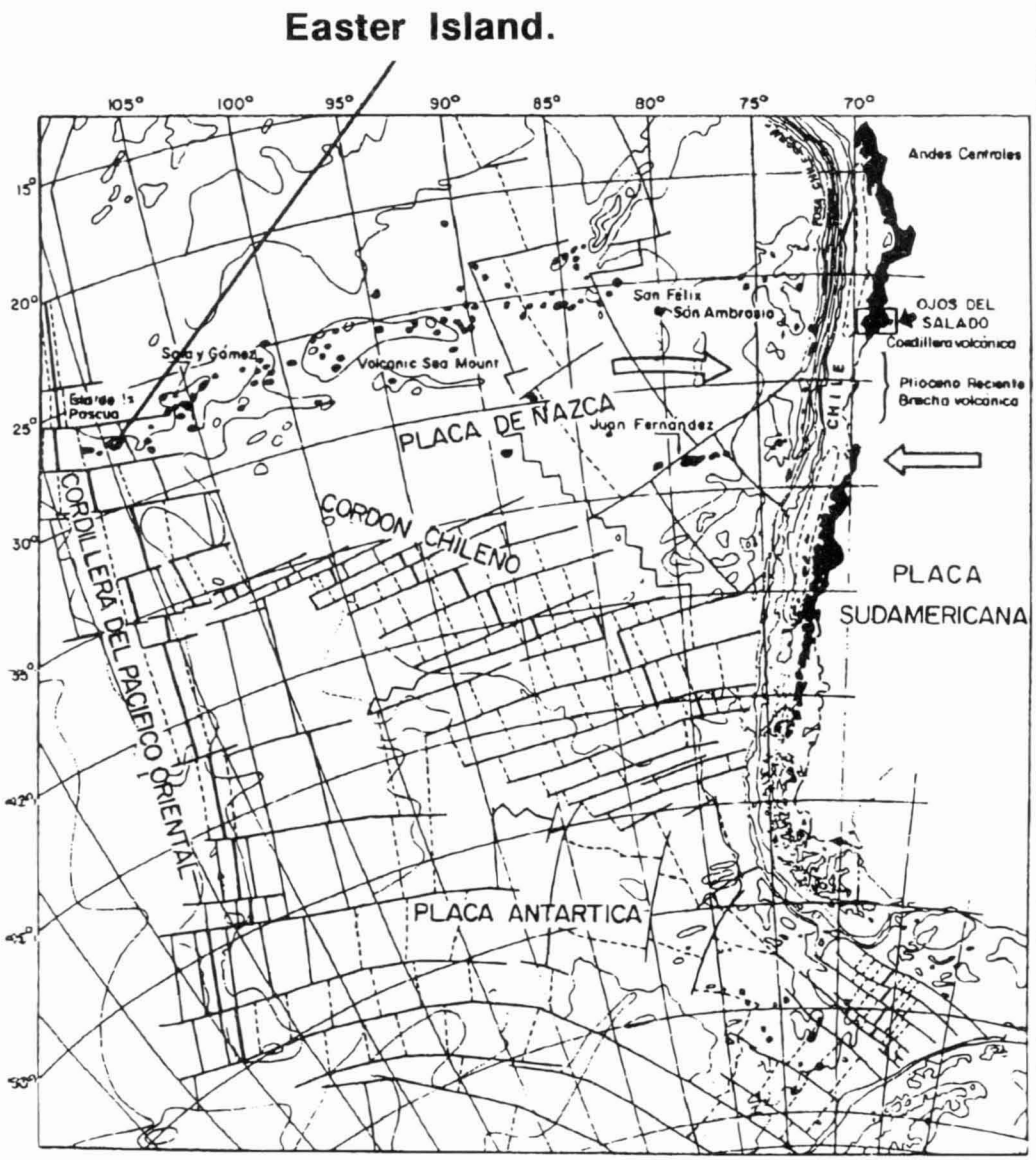


Figure 2. Showing the location of Easter Island in relation to the tectonic plates, faults and seamounts on the floor of the south Pacific.

written just after the island's conversion to Catholicism in 1868. This word probably derives from *papa,* meaning stratum rock, and it would translate as 'shifting stratum rock'.

Earthquakes on Easter Island are not isolated events and since 1950 the Department of Geophysics of the University of Chile has maintained a seismologic station on the island which, in recent years, has been implemented with equipment and aid from the University of Hawaii and the University of California. The seismic movements registered by this joint research plus earlier ones recorded by other stations in the last 100 years, having an epicenter in a 400 kilometer radius of Easter Island and measuring over Ms = 4.5, can be observed in Fig. 5. These results, plus the present knowledge of the bathymetry, morphology and geology of the surrounding area (Mammerickx *et al.* 1975, IHB/IOC 1982) carried out by the French oceanographic vessel Jean Charcot in 1985-87 (Francheteau *et al.* 1988) and by other US oceanographic vessels in recent years, prove beyond doubt that Easter Island is located in a very active volcanic zone and therefore most probably suffered earthquakes of varying magnitudes over past ages or even experienced periods in which seismic activity could have lasted for months or even years.

If this occurred when the island was inhabited, it would be incomprehensible that only the Rapanui word for this phenomena survived, and that the destruction produced on such occasions were not mentioned in oral traditions of the island, especially if its effect toppled the megalithic stone statues.

The ethnological record

According to the ethnological record some traditions could be interpreted as accounts of the statues being thrown down by an earthquake. Only one tale mentions that the statues were toppled during inter-tribal warfare. The authors are aware of the dangers involved in the uncritical use of oral traditions, as some of these stories evidently do not correspond to real facts that occurred in the past, but others may embody a reflection of former events. Some of these oral traditions were first recorded during the last century and are still remembered in the same form today.

The following tales can be interpreted as earthquake-caused damage at Ahu Tongariki. First recorded by Routledge (1919:173) and later by Métraux from a different informant in 1936 (1971:87), both versions are similar but Métraux's is more detailed.

"A priest (*ivi atua*) came down from Virivovo. He entered a house near Vai-maho. The men and women living in the house had eaten all the fish, the lobsters and the congers without leaving anything for the *ivi atua*. When he came into the house he asked 'Where is the fish, the lobsters and the congers you left for me?' They said, 'It is finished' He answered, 'All right.' He slept in the house. With his foot he pushed the supporting post (*oka pou*) of the house. The inhabitants of the house heard a loud noise, made by the falling statues of Ahu Tongariki. At dawn the men of this

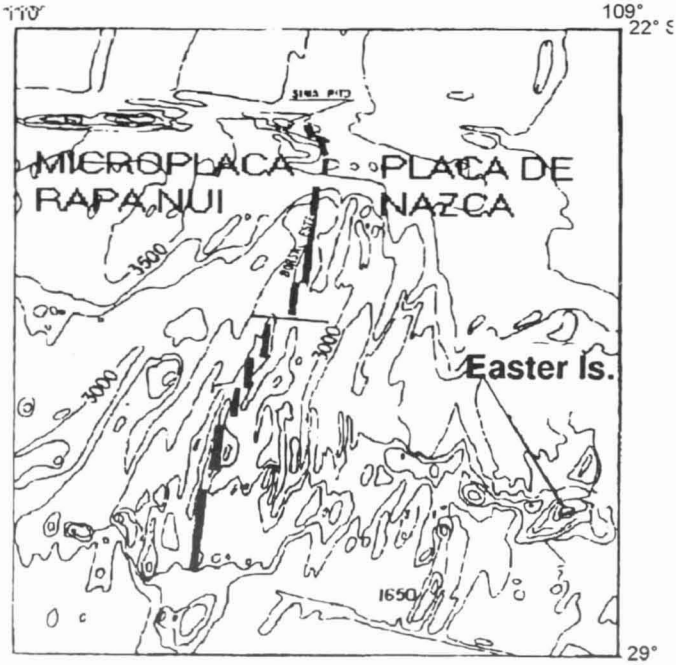


Figure 3 Bathymetric map of Easter Island Area.

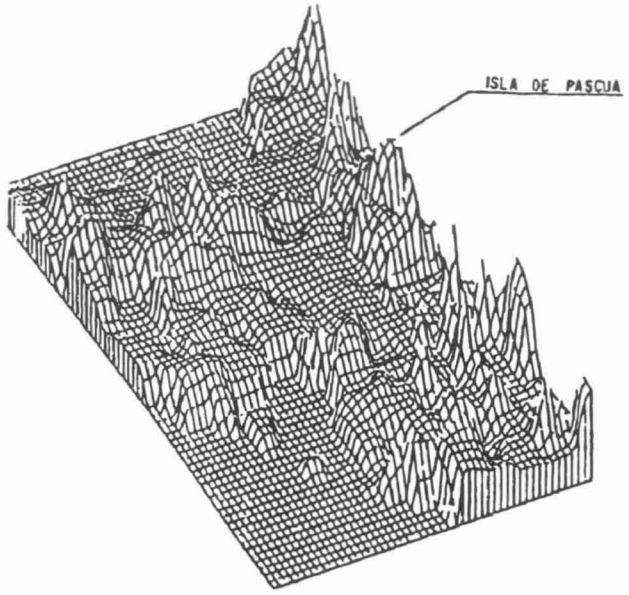


Figure 4. 3D graph of submarine morphology in the vicinity of Easter Island.

house said, 'When we where asleep the *ivi atua* pressed the post with his foot and caused the statues to fall. It is because we did not give him fish, conger and lobster.'"

Routledge's version differs slightly from the former in that the priest tapped his foot against the stone foundations of the house, thus causing the statues on Ahu Tongariki to fall.

It is interesting to note that the only statue fragment at Tongariki that remained standing upon its pedestal since pre-contact times was the lower part of the most westwardly *moai* of this platform (refered to as statue N° 15 in the reconstruction of Ahu Tongariki.) This statue was quarried in an oblique position in regard to the strata of the volcanic tuff and, presumably, when the earthquake shook the *ahu*, the statue jumped upon its pedestal thus shearing the statue in two. The heavier part (the head and the front part of the body) landed on the inclined ramp of the platform, leaving a wedge-shaped fragment of the lower back part standing.

Geiseler (1995:35), who visited Easter Island in 1886 reported that ". . . they attribute the collapse of the idols to a nocturnal battle among the gods when the stronger gods

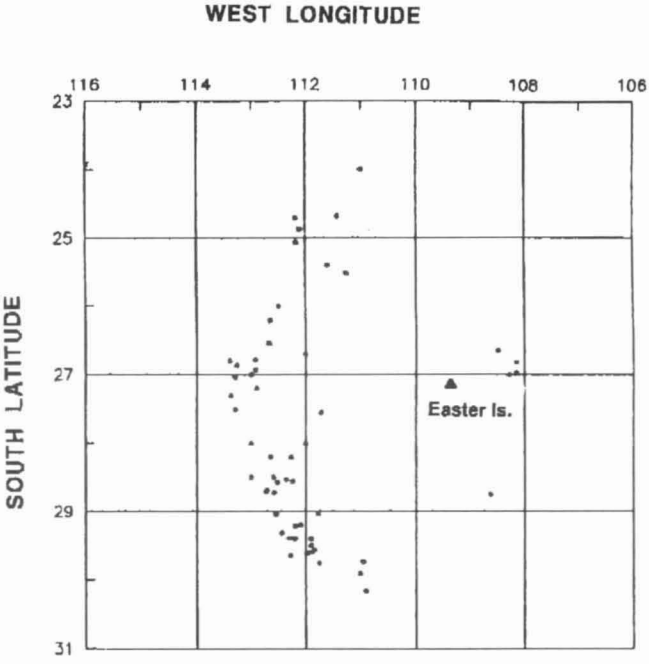


Figure 5. Seismic activity in an area of 400 km around Easter Island between 1897-1991. Seismological Service, University of Chile.

chopped off the heads of the weaker ones."

Edwards, in the 1960s, was told by several elders that they had experienced earthquakes during their youth and they mentioned that their parents and grandparents had felt them in past years. When asked if these earthquakes had knocked down the statues, they mentioned that they did not know exactly how they had fallen, except for those on Ahu Tongariki, which had been thrown down by an evil priest (as described above). Others owed their fate to a battle between the gods that took place one night in the remote past, or to witchcraft.

As for traditions that mention how a statue was deliberately thrown down, the earliest reports of destruction during warfare can be attributed to Father H. Roussel, the first priest to live on Easter Island. Roussel apparently believed that everything had been destroyed during wars although the other missionaries with him on the island do not mention this possibility. As we noted, tales describing strife are quite common and well remembered by the older generation. The

many accounts they told about warfare described events with utmost precision, including the sex, names, rank, dress, and other more intimate details of the participants, to the delight of the audience. They also related the names of houses and villages that were pillaged, and how the statue Ahu te Pito Kura was thrown down during one of these battles.

This latter story was also documented by Routledge (1919:173). And it is interesting to note that Te Pito Kura was the last statue to remain standing on the island and the second largest to have ever been transported from the quarry and placed upon an altar. It was named 'Paro' and weighed approximately 98 tons without its topknot. Apparently this occurrence happened by the end of 1835 or by the beginning of 1836 as, after this date, no one mentions it as standing. Routledge, in her manuscript, gives the names of those who overthrew the statue—ancestors of living people at the time—and she also noted the group to which they belonged: "The vandals were the group of the Tupahotu-o-uta, who had a grudge against the Tupahotu-oone, another ramage of the same group, over the death of a woman that had been captured and eaten by the Tupahotu-oone. To revenge her death the son captured thirty of the Tupahotu-o-uta in a cave and they were consumed. The statue was toppled in one of the struggles that followed this slaughter".

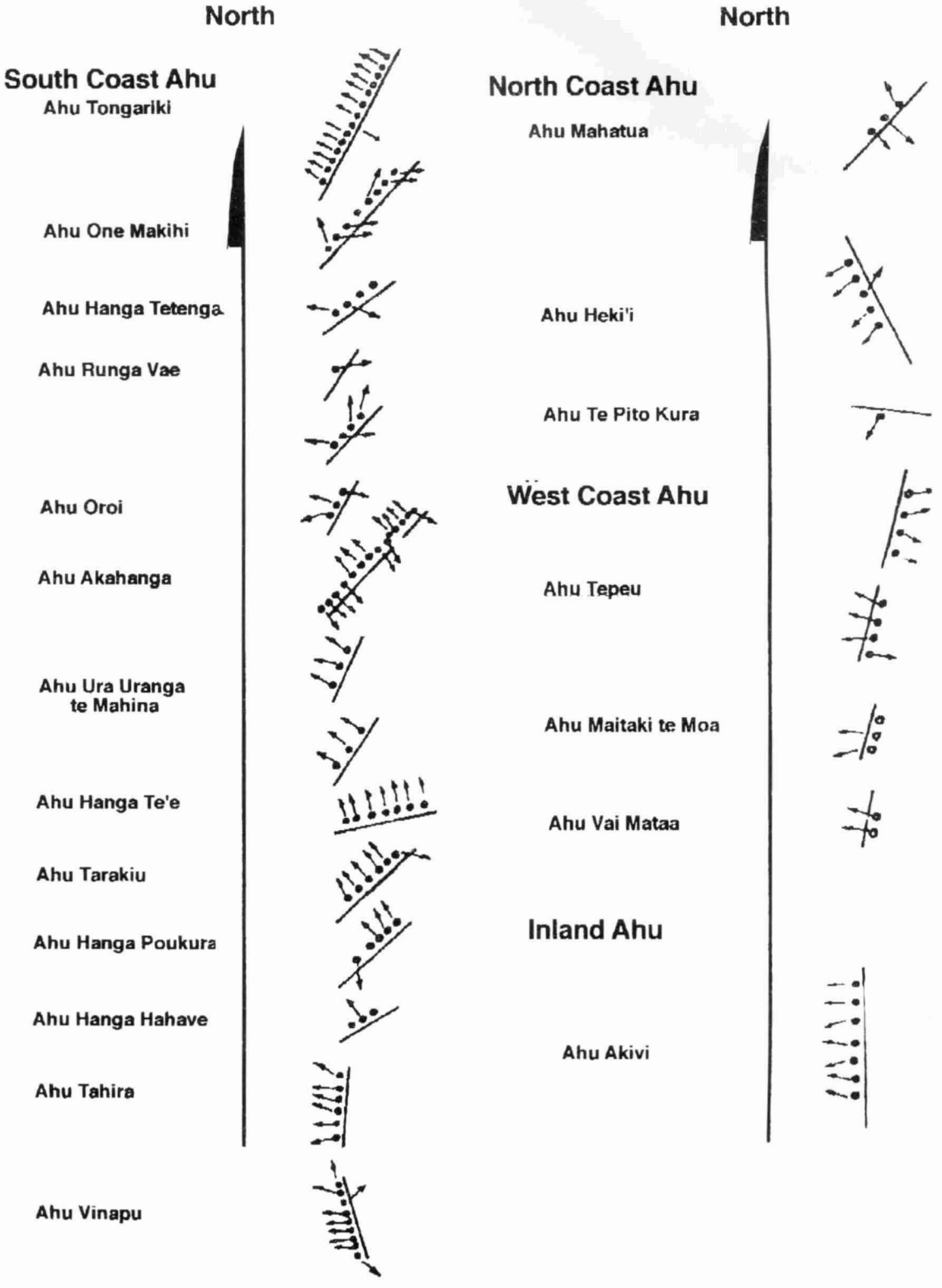


Figure 6. Directions of Ahu and fallen statues, with respect to north.

Based on this story and because most of the statues lay fallen on their faces as if they had been deliberately thrown

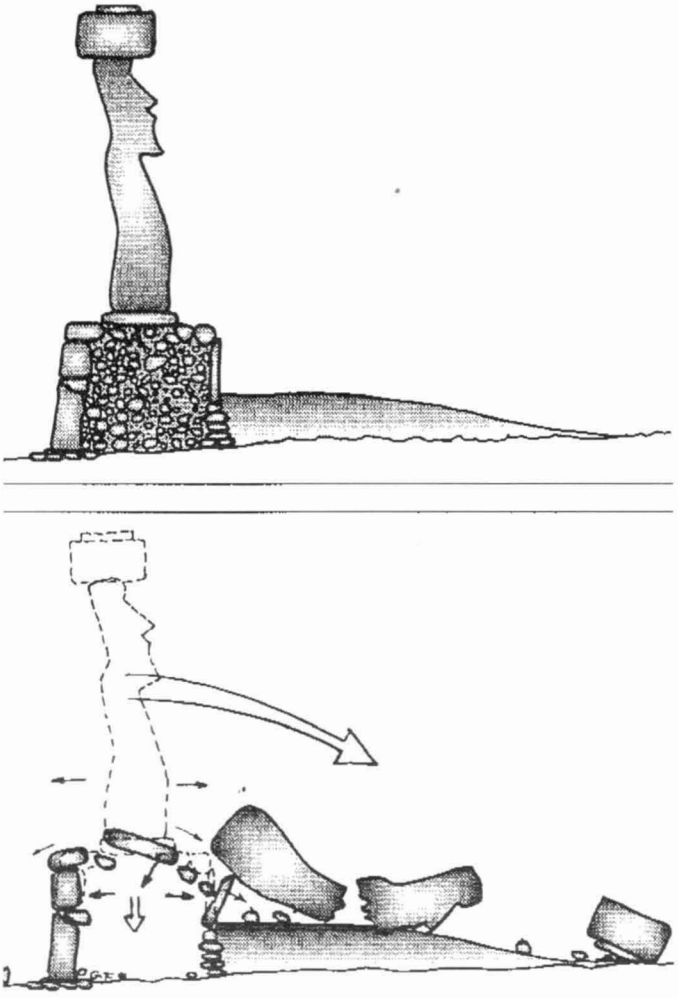


Figure 7. Seismic acceleration tends to burst the container of rubble fill of the ahu at its weakest point, in this case the front slab paengas, causing the statue to fall forward.

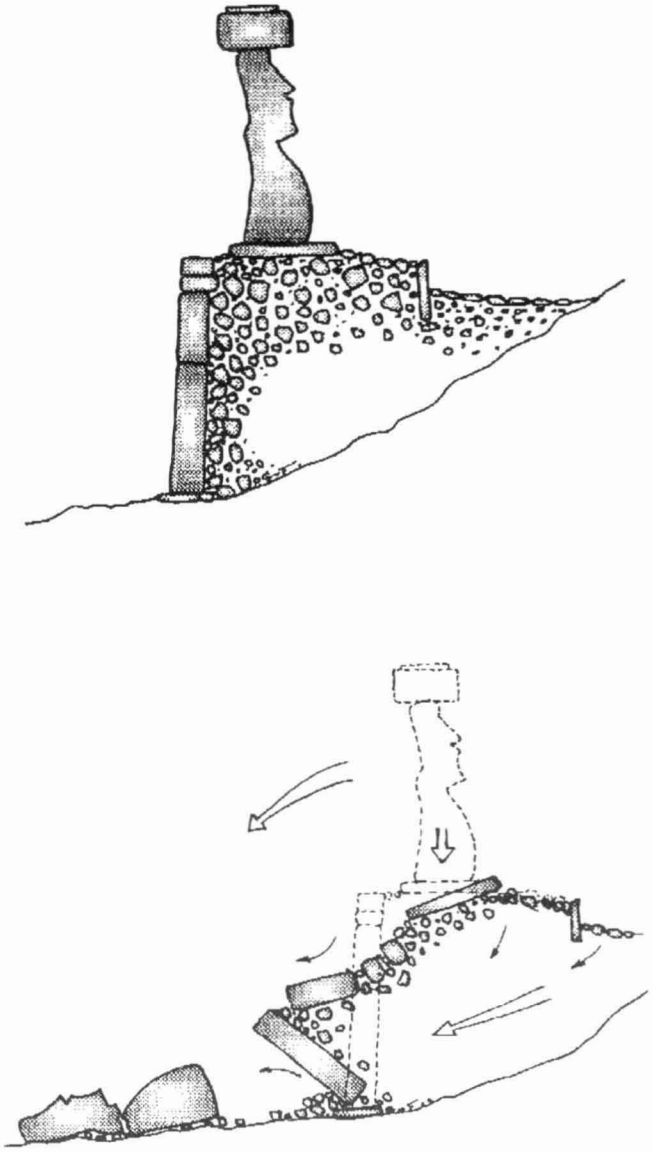


Figure 8. The case in which compression forces rupture the container of rubble fill causing the statue to fall backward.

from the altars, Routledge deduced that "Moreover, the conclusion that the images owed their fall to deliberate vandalism during internecine warfare is confirmed by knowledge, which still survives, connected with the destruction of the last one" (*Ibid.*). This indicates that her conclusion, that they had been thrown down during warfare, was supported by this tale only.

The only other deliberate defacing of statues recorded by Routledge refers to an attempt to behead one of them standing on the outside slope of Rano Raraku quarry during a feud between the Miru and the Gnaure of Akahanga (Routledge 1919).

The toppling of statues that were in transport is attributed by some of Routledge's informers to the wrath of a female *ivi atua* or sorcerer who apparently acted as a priestess for those who transported the statues from the quarry to their *ahu*. During some festivity she was denied food and, in a fit of anger, she ordered the workers to abandon their work. That night the statues fell which, incidentally, would indicate that some of them were transported in an erect position.

A similar tale recorded by Englert (1974:105) mentions that; "Three men went fishing and caught a lobster that was exceptionally large. They made an earth oven and cooked the lobster. An old woman who cooked the food for the statue carvers was not there when the earth oven was opened, and no food was put aside for her. When she returned she demanded her portion of the lobster and when they told her nothing was left, she cried in rage and shouted to the statues 'Fall down!' and that caused them to fall." In this legend it is not clear if the statues that were being transported fell down or if it refers to all the statues that were standing upon altars.

A Structural analysis of the Easter Island Ahu

If we consider that most of the statues fell during an earthquake and only a few were later toppled during periods

of inter-island warfare as indicated by the oral traditions, we would have to find undeniable traces of this seismic movement upon the *ahu*.

During the present research we examined a total of 36 *ahu* with statues plus numerous other structures including a large number of semi-pyramidal ones. Unfortunately, as the latter are usually built out of small stones, it is very difficult to establish if the damage was caused by vandalism or by earthquakes. Of the 36 *ahu moai,* 22 were chosen for further detailed analysis to determinate possible structural damages they might have suffered from the effects of mayor earthquakes. Those *ahu* we studied carried a total of 111 statues, but others may remain interred in the ruins. General measurements were taken and drawings were made of their structural units, type of filling, and their direction with regards to the north, the number of statues, and the position in which they fell (Fig.6).

Some of the general characteristics, shared by most *ahu moai* and almost a majority of the religious structures, is that they were built in areas where there was a flow of diaclase lava, which served as the prime building material for the structure. Thus the amount of stones that needed to be transported was minimal. These fragmented lava prisms, resembling 'corn kernels' (each rock is already separated from its neighbor by cooling fractures), could be easily removed by prying and provided the builders with a large supply of naturally adjusted rocks with which to build the proposed structure. In most cases larger prismatic blocks were laid directly on the rock stratum or upon the remaining lava flow in order to form the foundations of the retaining wall and usually were rearranged following the natural pattern of the lava flux so, in general, they show a fine adjustment.

All *ahu moai* are composed of at least three main elements; A central platform upon which the statues were placed on pedestals, a pair of wings that extend towards both sides of the platform and, at the foot of the central platform's front wall, there was an inclined plane or ramp that ran all along the front of the platform and continued to the very tip of both wings. Besides these elements, some *ahu moai* have a facia of red scoria blocks placed upon the front slab wall; associated crematoriums or cysts; and other elements that do not generally interfere or alter the structural characteristics of the monument.

The central platform, upon which the *moai* stood, can be compared to a rectangular box, delimited on its back side by the retaining wall of the *ahu*. These can measure from 1.20 to nearly 6 meters in height. The retaining wall is generally inclined inwards to obtain greater stability. The front and ends of this box-like platform are delimited by an alignment of cut basalt slabs that measure between 0.80 to 1.10 meters in height. These slabs or *paenga* are rectangular and measure between 0.10 to 0.20 meters in width by 0.90 to 1.30 meters in height and 1 to 4 meters in length. These are laid upon their longitudinal axis and, to keep them upright, are buried 0.20 to 0.30 meters into the filling of the central platform. The platform filling was composed of loose rubble of different sizes, depending on the availability of material in the surrounding area. In the places assigned to receive a statue, larger stones were occasionally placed to support the pedestal and give it more stability.

In all cases the stone components of the *ahu* were loosely tied together by the simple weight of the superimposed stones and by the adjustment of the polygonal prisms. This system had minimum static and dynamic stability and would not respond appropriately to natural events, which explains the ruinous state in which they are found today.

Stability model

An analysis of those *ahu* that were sufficiently well preserved to permit us to obtain information about their structural behavior shows that the builders were confronted with serious problems. Although the retaining wall of the *ahu* usually was built with material found *in situ*, the pressure of the filling plus the pressure exercised by the weight of the statue would generate a static instability upon the wall of the central platform. These pressures, in some cases, made the wall crumble behind the statues. Besides this, the giant megalithic stone statues of varied dimensions and weights caused further complications for the builders because, if the statues were not level and plumb, they would fall over even without an earthquake.

To stabilize the statue upon the altar, it was fundamental to control the base that generally was formed by one or more stone slabs laid horizontally and probably aligned with the horizon. Theoretically, if the statue was perfectly plumb and level, then the elliptical dimensions of its support would determinate its static and dynamic stability, while its amount of instability is determined by the force it exercises upon the retaining walls of the central platform plus the force exerted by the terrain upon the bases.

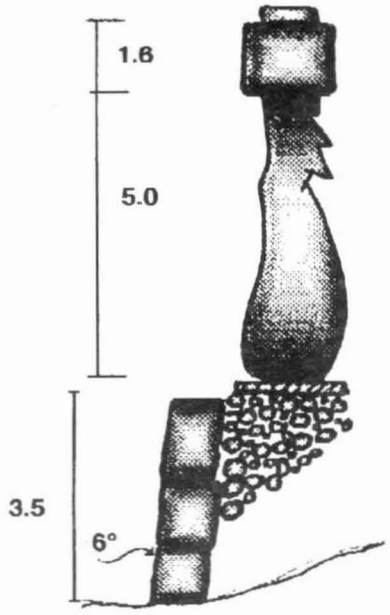
In case of an earthquake, the seismic acceleration upon a statue would alter the rubble filling and pressure would affect the retaining walls of the central platform box. The platform would tend to burst open at its most vulnerable point, usually the front slab *paengas*. These would be pushed forward, permitting the filling to spill out from under the base of the statues, causing them to fall forward upon the inclined ramp in front of the *ahu* (Fig. 7). In those cases in which the retaining wall of the *ahu* was more vulnerable to the compression exercised by these joint forces, the statue would then tend to fall backwards, as occurred at Ahu Vai Uri and the west wing of Ahu Akahanga (Fig. 8).

Four examples of unstable *ahu* that appear to have been destroyed by earthquakes

The structural analysis of these four *ahu moai* show the high degree of vulnerability that these structures have, even to low magnitude earthquakes. These examples also summarize most of the situations encountered in the different architectural forms of the *ahu moai*.

Ahu Tahira at Vinapu

Structural study of the *ahu*; weight calculus.
Topknot: d = 1.70 m, h=1.60 m, Volume = 3.63 m^3
density of tuff = 1550 kg/ m^3
Weight of topknot = 5626.5
Statue : (elliptic basal section 2.25x 1.10), h = 5m
Volume = 4.85 m^3
Weight of Statue = 7517.5 kg.
Structural behavior: S= 0.14 =A/ag
Topknot: 5626.5 X 0.14 = 787.71 kg.
Overturning point: 787.71 kg X 5.8 m= 4568.7 kgm
Statue: 7517.5 Kg X 0.14 = 1052.45 Kg
Overturning point: 1052.45 kg X 2.5 m = 2631 kgm
Joint overturning point: = 7199.7 kgm
Response in optimum conditions :
Mr = 13144 X 0.55 +7119.2 > 7199.7 kgm

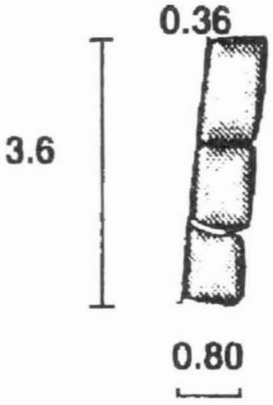


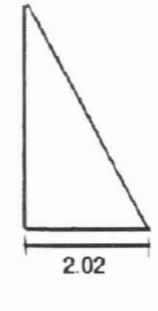
Note: If the statue was perfectly aligned vertically and had a leveled base.

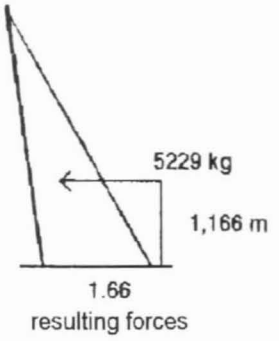
Analysis of the stability of the main retaining wall:
Filling: Rubble 0-0.30
< internal roll: 30°
Amount of blank space: 35%
Weight: = 1800 kg/ m^3

Overturning action of the statue on the retaining wall
(13144 kg (weight of statue)
Total exertion: 1801 kg
Weight of wall: (width 1 m) = 0.8 m X3.5 m X 1 m X 2.650 kg/m3= 7.420 kg
Exertion of wall upon filling (6° inclination)cos 84° x 7420 kg = 775.6 kg
Total exertion = 11025.4 kg
Overturning point: 11025.4 kg X 1.166 m = 12555. 6 kgm.
Mr = 7420 kg X 0.40 m = 2968 kgm

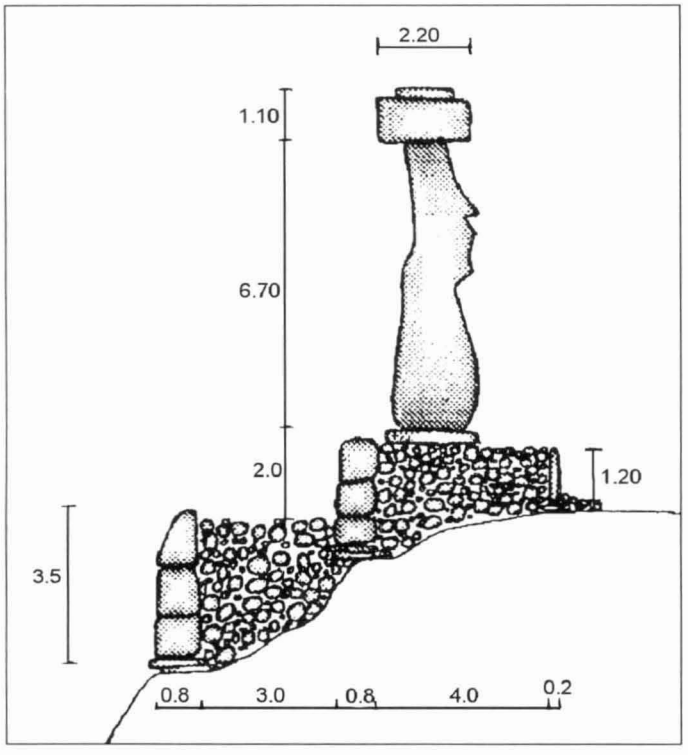
Conclusion: in each position in which a statue is standing, there is an instability of 9887.6 kg. This explains the situation found in most of the altars where, with the slightest seismic movement or flooding, the passive force of the filling would become active and the statue would topple.







Ahu Ura Uranga te Mahina

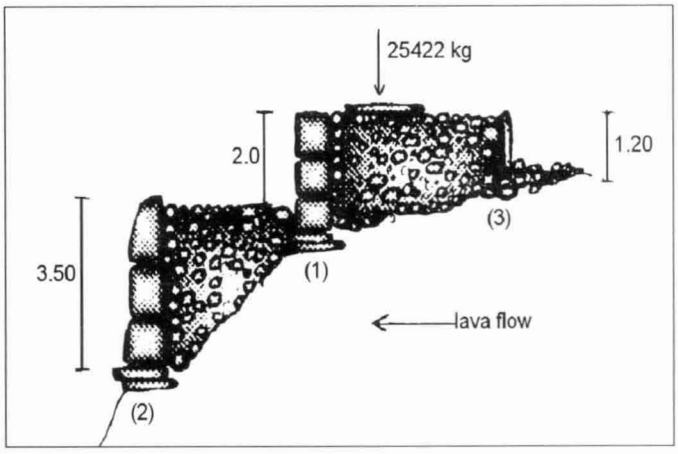


Structural study of ahu; Weight calculus
Topknot: d= 2.20 m, h = 1.20 m,
Weight of tuff =1550 kg/ m^3
Volume: 4.56 m^3
Weight of topknot: 7070 kg
Statue: Elliptic basal section =3 m X1.5 m h=6.70 m
Volume: 11.84 m^3
Weight of Statue: 18352 kg.

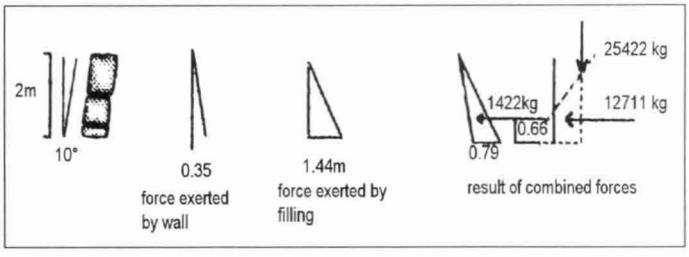
Stability of the group of moai

Total weight = 25422
Maximum seismic security factor in optimum conditions of alignment and leveling S= 0.16
Overturning point: 1131.2 kg X 7.3 m = 8257.76 kgm
Statue: 9836.672 X 0.16 = 2936.32 kg
Overturning point: 2936.32 kg X 3.35 m = 9836.67 kgm
Joint overturning point: 18094 kgm

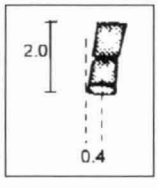
Structural reply in optimum conditions.
Mr = 25422 kg X 0.75 m = 19066 kgm > 18094 kgm
(If the statue and its topknot were perfectly aligned and had a leveled base)



Structural analysis of the retaining walls



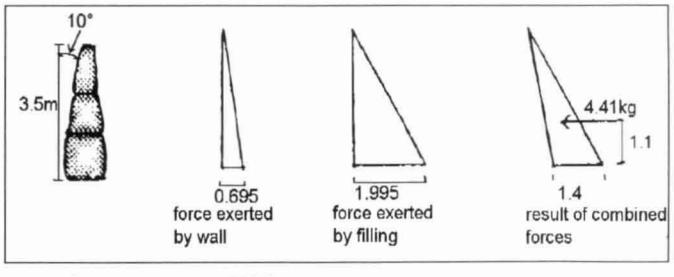
Wall (1)
Pushing forces: 1.- filling 2.- statue
Total force exerted upon wall (1):
H =1422 kg + 12711 kg - (wall's weight)
Wall: 0.80 m X 2 m X 1 m X 2650 kg/ m^3 = 4240 kg
Cos. 80°= 0.17 X 4240=736 kg
H =13397 kgm overturn = 13397 X 0.666 =8922 kgm
Wall's reply to exerted force: Mr = 4240 kg X 0.40 m = 1696 kgm



Unbalance: 7226

Note: This wall is destroyed

Wall (2)
This wall behaves as a container for the filling. Both walls are laid upon stones or slabs that are lying upon the stratum rock of the lava flow.

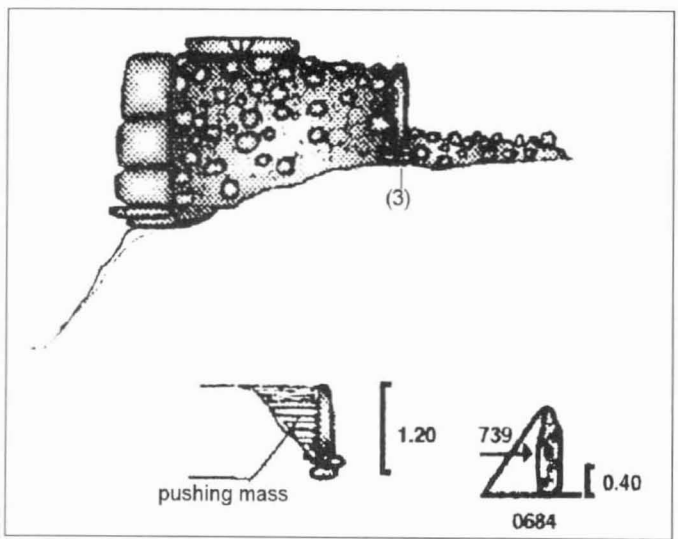


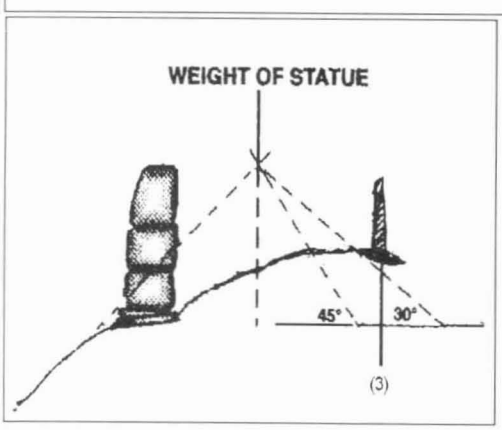
Total force upon wall(2):
Filling: 4410 kg - weight of inclined wall (< 10°)
Weight of wall: 0.8 m x 3.5 m X 2650 kg / m^3 = 7420
Cos 80° X 7420 kg = 3122 kg
Total force exerted: 4410 kg -1288 kg =3122 kg
Overturning point: = 3122 kg X 1.16 m = 3621.5 kgm

Wall's reply to exerted force: Mr = 7420 kg X 0.40 m = 2968 kgm
There is an unbalance of: 653.5 kgm.

Wall (3)
It is important to note that this slab wall measures 1.20 m in height by 0.20 m in width and that similar slabs dress most of the *ahu moai* faces around the island. These front *ahu* slabs are only affected by the force that the filling might exert against them .

MODEL

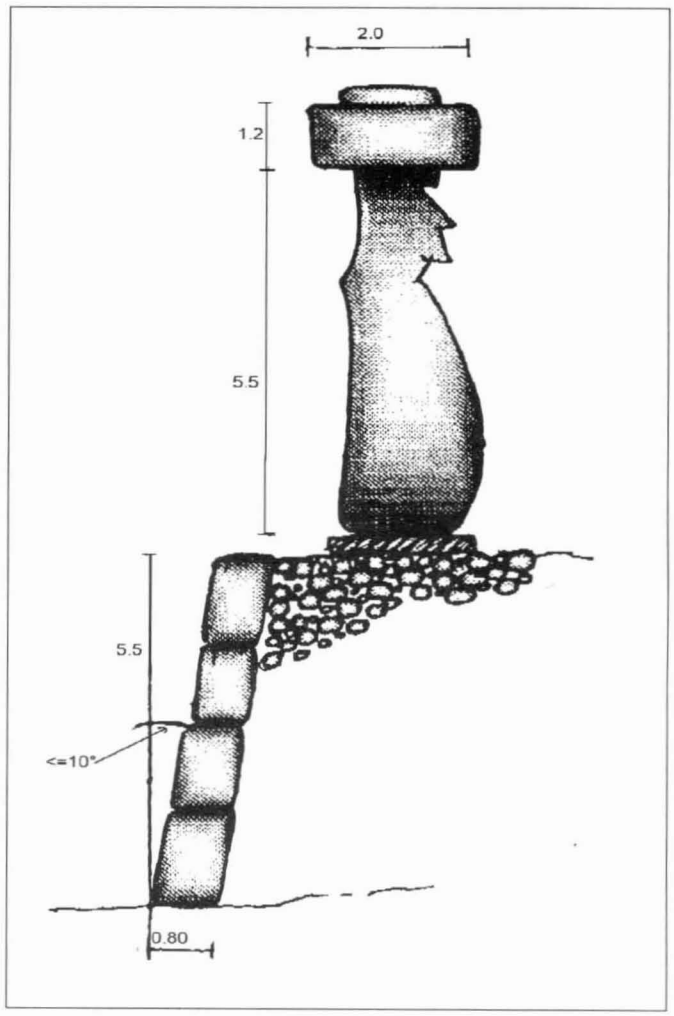




Overturning point: 739 kg X 0.40 m = 296 kgm
Gravitational equilibrium of wall: 0.20 X 1.2 X 1 X 2650 kg / m^3 = 636 kg
Mr = 636 kg X 0.10 m = 63.6 kgm < 296 kgm (soliciting)

Summary: In this diagram it is evident that the wall (3) has no compromise with the decomposition of the *moai's* cargo. If the decomposition is about 45° or a maximum of 30° it does not compromise the walls axis, but they would be severely affected by the active force of the filling during an earthquake. This analysis can be considered valid for all walls with these characteristics upon other *ahu moai*

Ahu Aka Hanga



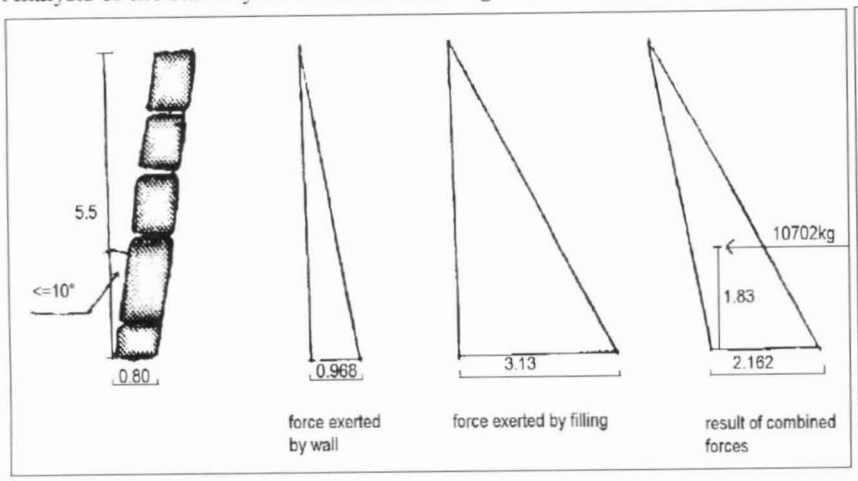
Structural study of ahu:

Weight calculus
Topknot: d= 2m, h = 1.20 m weight of tuff 1550 kg/ m^3
Volume: 3.76 m^3
Weight of topknot : 5843 kg
Statue : Elliptic basal section =2.50 m X1.20 m, h=5.5 m
Volume : 6.43 m^3
Weight of Statue : 10044 kg.

Structural behavior : S = 0.15 = A/ag
Topknot : 5843 kg X 0.15 = 876. 45 kg
Overturning point: 876.45 kg X 6.1 m = 5346.34 kgm
Statue: 10044 X 0.15 + 1506.6 kg
Overturning point: 1506.6 kg X 2.75 m = 4143.15 kg
Joint overturning point: 9489.49 kgm
Structural reply in optimum conditions.
Mr = 15887 kg X 0.60 m = 9532.2 kgm > 9489.89 kgm

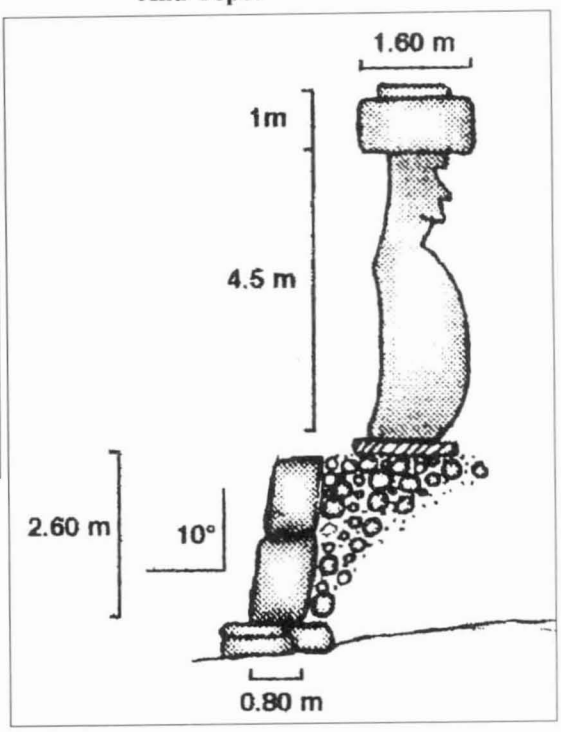
Note: If the statue and its topknot were perfectly aligned and had a leveled base

Analysis of the stability of the main retaining wall

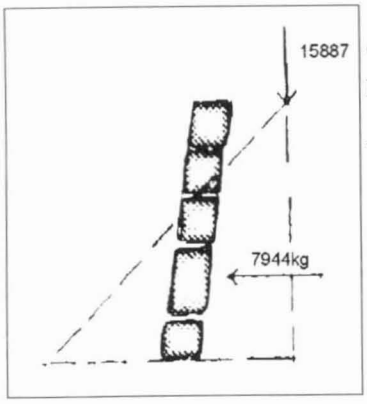


Filling: gravel 0-0.30 m
< internal roll 30°
Blank space 35%
Weight 1800 kg / m^3

Ahu Tepeu



Falling point of the statue on the retaining wall

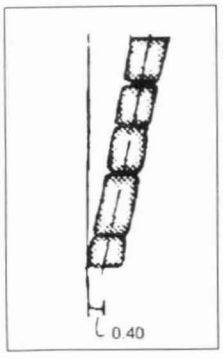


Total force exerted: 18645 kg

Weight (width =1 m): 11660 kg

Exerted force of the wall upon the filling: < 10°= 2025 kg (Cos. 80°)

Total force exerted = 16621



Overturning point: Mr = 16621 kg X 0.40 m
= 4664 kgm

Wall's reply to exerted force: Mr = 11660 kg X 0.40 m
= 4664 kgm

There is an unbalance of : 25752 kgm

Structural study of *ahu*: **Weight calculus**

Topknot: d=1.6 m, h = 1 m,
Volume: 2 m^3 ,weight of tuff 1550 kg/ m^3
Weight of topknot: 3116.45 kg.

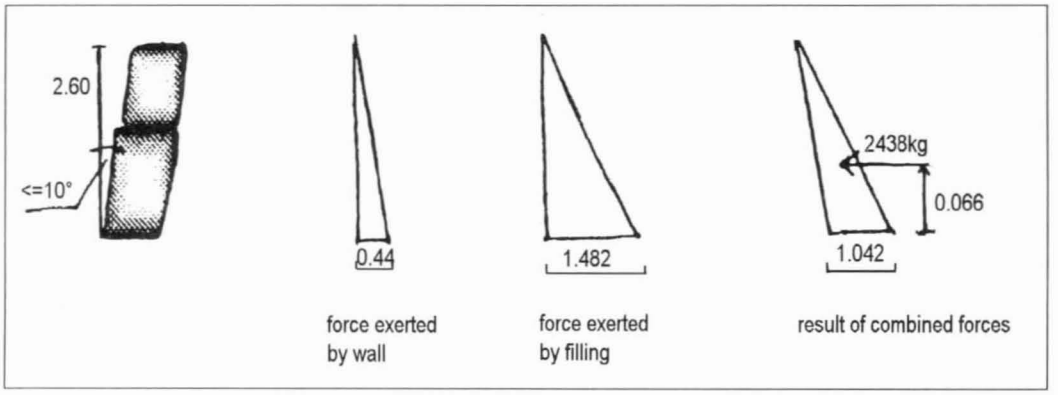
Statue: Elliptic basal section =1.50 m X1 m, h= 4.5 m
Volume: 2.65 m^3
Weight of Statue: 4108.6 kg.

Structural behavior: S = 0.14 = A/ag
Topknot: 3116.45 kg X 0.14 = 436.30 kg
Overturning point: 436.30 kg X 5 m = 2181.5 kgm
Statue: 4108.6 X 0.14 = 575.2 kg
Overturning point: 575.2 kg X 2.25 m = 1294 kg
Joint overturning point: 3475.5 kgm

Structural reply in optimum conditions.
Mr = 7225.05 kg X 0.5 m = 3612.5 kgm > 3475.5 kgm

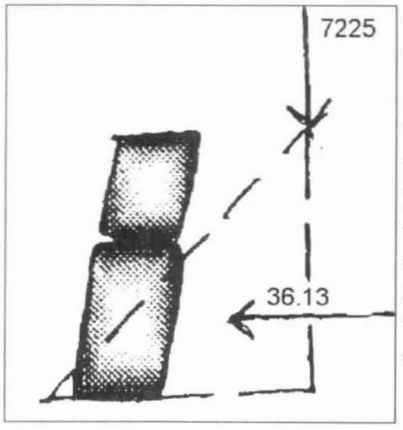
Note: If the statue and its topknot were perfectly aligned and had a leveled base.

Analysis of the stability of the main retaining wall



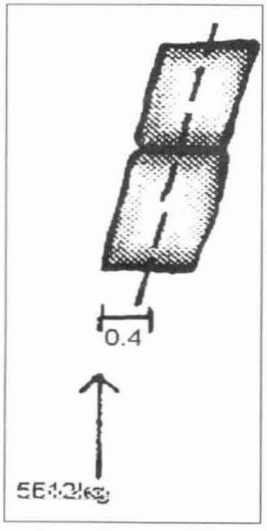
Filling; gravel 0-0.30 m
< internal roll 30°
Blank space 35%
Weight 1800 kg / m^3

Falling point of the statue on the retaining wall



Total force exerted: =6051 kg
Weight (width of 1 m wall): 5512 kg
Exerted force of the wall upon the filling: =957 kg
(10% inclination)
Total force exerted = 5094kg

Overturning point: 5094 kg X 0.866 m= 4414.6 kgm.



Wall's response

Mr =5512 kg X 0.4 m
= 2204.8 kgm

There is an unbalance of :
25752 kgm.

As it can be observed in all of the four cases the *ahu moai* show great structural instability.

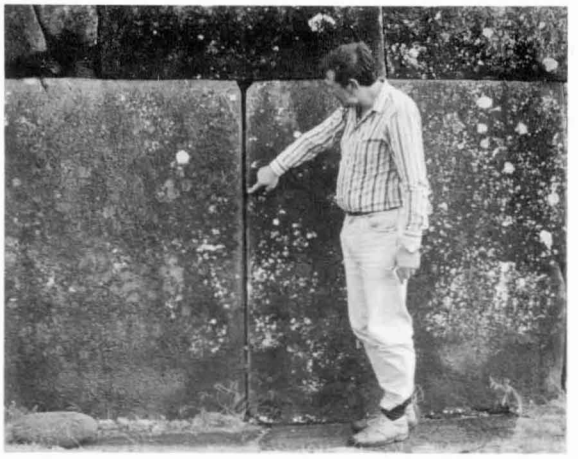


Figure 9.Edwards points out a separation in the sea wall at Ahu Vinapu which he suggests was caused by a violent earth movement.

Figure 10.Statue pedestal at Ahu Te Tenga on the south coast with crack running through its center. It is postulated that this crack occurred as the result of an earthquake that caused a vertical movement. The statue's up and down motion broke the pedestal causing the statue to fall forward.

When did the statues fall?

To be able to determinate when the statues toppled we can refer to historical accounts left by the first Europeans to visit the island. Roggeveen, during his short stay, was able to see some statues standing upon an altar in Anakena but he does not mention seeing any fallen ones. This does not mean that earthquakes had not occurred by then. In fact, earthquakes could have toppled statues long before European arrival for no one mentions seeing Ahu Tongariki when they passed in front of Hanga Nui bay. This monument with its 250 meter long *ahu*, its 5 meter high wall, and surmounted by 15 statues with topknots that measured up to 12 meters in height, is something that could easily be observed even from far out to sea.

During Captain Cook's visit in 1774, a great number of large monumental statues were still standing on their platforms or *ahu*, offering an impressive view to the visitors as they cruised the coasts of the island. The exploration presumably carried them as far as Rano Raraku's quarries, by then abandoned and overgrown. On the west coast they were able to see several statues still standing, three on one *ahu* and another one, 20 feet tall with a 5 feet diameter *pukao* of red scoria, in the neighborhood. The statues from Ahu Tautira (A.D. 1550) on Hanga Roa bay were all standing at the time (Charles Love, personal communication 1983). The first report of fallen statues observed by Europeans is from Cook's visit and it refers to Vinapu.

Subsequent arrivals to the island, such as la Pérouse in 1786, saw that some of the altars on which the statues were once standing had gone to decay while others are reported as lying down (Langle 1797: 331). In 1804 the first Russian expedition into the Pacific under the command of U. F. Lisjanskij (1814) stopped by Easter island but bad weather prevented a large party from landing. On sailing around the island they were able to count 20 standing statues, four of which were in the bay of Hanga Roa and the others on seven monuments they saw after rounding the south tip of the island and cruising along the south coast. This means that, in the 30 years that had elapsed since Cook's visit, a large number of statues had fallen down, and many of them between Cook's visit and that of La Pérouse in 1785.

In 1828 Morenhout mentions seeing standing statues on the north coast and two years later Orlebar (1833:9) mentions three tall figures and several huts at a distance of three or four miles down the eastern side of the island, just before they cruised around the south point of the island. These statues could correspond to Vinapu 1 or 2. He adds that all along the shore they observed piles of stones surmounted by one white pebble and with two or three small carved images. This indicates that shortly after the fall of the images, the ruined altars were converted into semi-pyramidal type structures and the statues were buried or concealed by the large number of stones piled on top of them.

A Russian Expedition under the command of O. E. Kotzebue paid a short visit to the island in 1816 and was able to observe only two altars with statues still standing on the south coast. The statues noted twelve years earlier by Lisjanskij (1814) at Hanga Roa bay had toppled.

Based on reports of the different visits of these navigators it is possible to develop the following chart shown in Table 1 and to draw several inferences:

A) Reports from Roggeveen's expedition, although they do not permit a detailed identification of all the *ahu* sighted, indicate that no fallen statues were observed.

B) Those statues standing on Ahu Tautira and Orongo on the west coast fell between 1804 and 1816, and Ahu Vinapu 1 or 2 underwent further damage during this time span, as only two statues were left standing.

C) The lonely statue seen by Lisjanskij (1814) on the north coast was most probably 'Paro' on Ahu Te Pito Kura, as we know it was still standing until 1836.

Therefore, some of the statues on the *ahu* fell or were thrown down between 1874 and 1886 and the majority of those that were left standing fell or were thrown between 1804 and 1816.

Summary

1.- The geological, geophysical and seismological studies carried out in the Easter island area demonstrate beyond doubt that Easter Island is an active Pleistocene volcanic island.

2.- The island has been subject to earthquakes for a long time as demonstrated by the historical records. Those of a larger magnitude that certainly affected the island in the last 100 years had an epicenter located in the basal regions of the island, in a radius of 100 to 400 kilometers as shown in Fig 6. The last major earthquake to affect Easter Island had a magnitude of Ms 6.3 and it occurred on July 8, 1987. Its Epicenter was located at a depth of 10 kilometers and about 100 kilometers to the Northeast of the island.

3.- The way in which the principal *ahu moai* lay destroyed bears characteristic evidence that the structures were subjected to directional forces of nature and that most likely all of their statues toppled due to earthquakes.

4.- Earthquakes were known on Easter Island, they had a name by which to designate them and elderly people remember that this phenomena had been felt by their parents and grandparents in the past.

5.- It can be inferred from the oral traditions collected by Métraux (1971: 87); Routledge (1914-15: ms); and Geiseler (Ayres and Ayres 1995:35) that the toppling of the statues was a sudden event that took place during the night. Certainly the tale mentioned by Métraux and Routledge, relating how a sorcerer tapped or pushed the foundations of a house during the night to make the statues of Ahu Tongariki fall, must refer to a major earthquake that toppled those statues and probably many others around the island.

6- The historic evidence that describes how the statues were torn down during intertribal wars probably refers to a small number of statues that survived the earthquakes and that were latter toppled as described in the oral traditions as told to Bishop Tepano Jaussen. The idea that all statues were torn

Table 1. Ahu sighted by visitors 1772-1838

Visitor	Year	Altar or locality	Number of statues	Observations
Roggeveen	1722	Anakena bay		all statues standing
Gonzales	1770	Te Pito Kura	1	all statues standing
		Ahu Hekii	7	all statues standing
		other coasts		all statues standing
Cook	1774	Ahu Tautira	3	all standing
		Ahu Orongo	1	standing with topknot
		Ahu Tahai	5	standing
		Ahu Ko te Riku		standing
		Ahu Vinapu 2	9	four overturned and damaged, one standing had lost its hat.
		Between Vinapu and Rano Raraku		all standing except one, probably in transit
La Pérouse	1786	Ahu Vinapu 2	9	some standing, platforms in decay with fallen statues
Lisjanskij	1804	Ahu Tautira	3	standing
		Ahu Vinapu 1	6	4 standing
		Ahu Vinapu 2	9	3 standing
		from Ahu Vinapu to Ahu Tongariki		three more ahu with standing statues
		from Ahu Mahatua to Anakena beach		four altars with statues standing, the middle one with a single statue (Te Pito Kura?)
Kotzabue	1816	Ahu Tautira	3	statues fallen
		Ahu Orongo	1	statue fallen
		Vinapu 1 or 2		2 statues standing
Beechey	1825	Ahu?	4	standing
Moerenhout	1828	north coast		saw some standing images
Petit-Thouars	1838	Ahu Tepeu 1	4	all standing
		Ahu Tahai	5	all standing

down this way was first suggested by Father Roussel but is not corroborated by the other missionaries that were with him on Easter Island at the time. As Roussel acted as translator and informant to visitors until his departure from Easter Island in 1872, and had contact in later times with some of those who visited Easter Island, his views most probably influenced his guests, who thus validated his thoughts in writing.

7.- Of the 36 *ahu* that were first investigated and that represent 100% of the principal or largest structures of the island, a total of 20 *ahu moai,* comprising a total of 24 platforms were chosen as a sample for a more detailed study. These 24 platforms supported a total of 111 *moai*. It was observed that, in all cases, the fall of the statues was caused by a loss of leverage of the basal structure, and 80% of the statues fell inland. This occurred because the most vulnerable point of the building is the fragile and unstable front slab wall of *paenga* that would tend to burst open with minimum effort, letting the rubble filling spill out and thus destabilizing the megalithic stone statues. Due to the structural instability of the central platforms of all of the *ahu*, this could have occurred even during a medium or low magnitude earthquake.

This theory explains why many of the front line slabs of some *ahu* are slightly inclined. If they had been intentionally pushed forward to remove the filling from under the base of the statue in order to topple it, then it would not have been necessary to push forward all those slabs located between statues, or those close to the end of the platforms where no statue was standing. We see this in certain *ahu*. Mulloy encountered an example of this during the excavation of Ahu Vinapu but he attributed it to bad maintenance of the ramp. However, he found no explanation for the displacement of the frontal slabs (Mulloy 1961: 130).

"It is noteworthy that the ahu ramp does not seem to have been cleanly maintained at the time of the statues were pulled down, for the face of Statue 635 had several large irregular stones that were lying on the ramp at the time imbedded in it. This may mean that the ahu was not well cared for. Alternatively, these stones may have been thrown out immediately before the fall, in undermining operations, or may have rolled to this position from the central section core when nearby statues were pulled down.

The whole of the ramp side wall of the north half of the central section was displaced at this time. All but the lower course of the Middle Period red scoria replacements were toppled, and the Early period vesicular basalt slabs were tipped somewhat landward." (emphasis ours)

Additional examples in which the front slabs are pushed forward can be observed at Ahu Akahanga and Ahu Hanga Mai Hiku, but in this case some of the statues fell sideways pulling down those next in line and in other cases the statue jumped upon its pedestal fracturing it and then it fell in any direction.

8.- About 80% of the statues that are fallen upon the *ahu moai* in the island's periphery, as shown in Figure 9, indicate that they fell in a West-Northwest direction and 20 % of them towards the East-Southeast direction.

9.- The great majority of the statues appear to have fallen in a late period possibly between the late 1700s and the early 1800s, but they could also have fallen in earlier times. This could be one of the reasons why certain statues were recycled in *ahu* from time to time.

10.- After a period of seismic activity in which the majority, if not all, of the statues erected on ceremonial centers toppled, it would be logical to suppose that activities in the quarries would cease while the cycle of tremors and earthquakes continued, or until this phenomena was explained and rationalized. If the duration of one of these seismic cycles lasted over a period of several years, most probably the activities of statue building in the quarries of Rano Raraku would be abandoned

If statue building was resumed at a later date, most probably the carvers would finish those statues that were already in the process of been carved. Or they might experiment with new configurations such as the two kneeling statues at Rano Raraku, a form that could have been looked upon as being more stable. If there was little security that the statues would not fall once they were placed upon the altar, it seems logical to set them upright upon the outer talus of the volcano to await for better times. This may explain why a number of apparently completed statues seem to be abandoned outside the Rano Raraku quarries.

11.-There is no doubt that the outcome of such a devastating disaster would have profound consequences on all aspects of the culture. The ancestor cult and other religious concepts probably would undergo changes. This event could also explain why they spent an enormous effort in transforming most of the image *ahu* into semi-pyramidal ones by covering the whole structure with stones, a process which affected the great majority of the *ahu moai* and that apparently took place soon after the statues had fallen. This could represent a desire to cover the images and altars to protect them from further destruction by earthquakes.

12.- There is ample basis in the literature to assure that the fallen images continued to play a significant role until their conversion to Christianity, as symbols of supernatural power of the ancestors of the different tribes. The first missionaries were not allowed to step on them (Roussel 1864:ms) and later visitors such as Geiseler and Thomson also mention that the islanders still placed them in high esteem. This would tend to indicate that the ancestral image cult continued to play a significant role in the Late Period despite the internal strife that affected the culture.

Undoubtedly the occurrence of such great disasters upon a small island that constituted a universe must have brought innumerable consequences and changes, upon which we can speculate in the years to come. Nevertheless this paper shows that the downfall and changes that occurred during the Late Phase of the Easter Island culture were not all due to environmental degradation or overpopulation. It was also due to the unexpected and magnificent forces of nature that, one night in a past not long ago, most probably altered forever the islanders' beliefs and destiny.

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